

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Concurrent changes in physical activity and body mass index among 66,852 public sector employees over a 16-year follow-up: multi-trajectory analysis of a cohort study in Finland
AUTHORS	Tiusanen, Roosa; Saltychev, Mikhail; Ervasti, Jenni; Kivimäki, Mika; Pentti, Jaana; Stenholm, Sari; Vahtera, Jussi

VERSION 1 – REVIEW

REVIEWER	Bethany Barone Gibbs University of Pittsburgh
REVIEW RETURNED	23-Nov-2021

GENERAL COMMENTS	<p>Review of BMJ Open Manuscript 057692</p> <p>I enjoyed reading this article that reports groups of physical activity + BMI trajectories over a 16-year follow-up. Though interesting, a few suggestions could improve the paper.</p> <ol style="list-style-type: none">1. Line 138-141: Please comment on the validity/reliability of the self-report instrument used to measure physical activity. Cite any publications that evaluate these, if applicable. If not, describe how the questions were developed and any aspects of the instruments that would suggest the tool is valid.2. Line 140-141: Where were the MET-values for different activities obtained from? Please cite.3. Line 144: Similarly, do you have any data that suggests validity of self-reported height and weight in this cohort? Similar cohorts?4. Recommend swapping text in lines 171-176 as a table (Table 1); then the current Table 1 (goodness of fit characteristics) would be fine as a Supplemental Table. Nice to see the trajectory justification, but only for those that want to confirm the method was conducted correctly.5. Trajectory (1 through 4) should be marked on Figures 1 and 26. The text in 180-187 would likely fit better within the figures (as labels, e.g. for percentages of membership; and within a legend perhaps for the description of the PA level/BMI)7. Figures 1 & 2: the unit doesn't seem correct on the y-axis. Is this MET-hr per week – seems very high if so? MET alone is an intensity not volume of activity.8. It is nice how the BMI levels are interpreted based on accepted cut points of normal/overweight/obese. Interpretation of physical activity levels throughout could be improved if anchored to WHO guidelines (i.e., 150 min per week of moderate activity - can be changed to whatever unit is being used). For example, this could allow for more concrete statements in line 238-239 (was high above normal guidelines? by how much?)9. Line 247 – MET-hr per week? MET/week is confusing.10. Conclusion (both in line 257 and abstract): I am not sure
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	<p>you've proven that changes in BMI and physical activity are interconnected. Slightly more correct might be to say that changes in BMI and physical activity co-occur, given the observational nature of the study.</p> <p>11. The objective states explicitly to compare age groups, but then this is not mentioned at all in the conclusions. What is the public health impact of the differences across age groups?</p> <p>12. Another limitation is only looking at physical activity, rather than all day activity profiles. See this reference: Gupta, N., Hallman, D.M., Dumuid, D. et al. Movement behavior profiles and obesity: a latent profile analysis of 24-h time-use composition among Danish workers. <i>Int J Obes</i> 44, 409–417 (2020). https://doi.org/10.1038/s41366-019-0419-8</p> <p>13. In general, I'm missing an interpretation of the importance of these findings and future directions for additional research. Could a section be added to the Discussion?</p>
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REVIEWER	Joshua Zadro University of Sydney, Institute for Musculoskeletal Health, School of Public Health
REVIEW RETURNED	28-Nov-2021

GENERAL COMMENTS	<p>I thank the authors for the opportunity to review this interesting piece of work. The authors aimed to examine concurrent changes in BMI and physical activity over a 16-year period and whether this was influenced by age and gender. The study is well-written, and mostly well-reported. The introduction provides a clear rationale for the study and the discussion gives a very clear summary of the findings and limitations. I only have a few minor comments which should be relatively easy to address:</p> <p>Methods</p> <ul style="list-style-type: none"> -Could the authors provide more detail about the FPS? (e.g. sampling strategy, total sample size, what questions they are asked) -What was the specific inclusion/exclusion criteria for this study? -A flow diagram would improve understanding of the selection of the sample -Could the authors add more detail about how the models/trajectories are chosen/generated in the analysis section? -Why was age stratified at ≤ 50 and > 50? Why not ≤ 40 and > 40 or ≤ 60 and > 60 for example? -Was there any adjustment for co-variables in the analyses? If so, how these variables were collected and analysed should be outlined in the methods <p>Discussion</p> <ul style="list-style-type: none"> -Line 246: can you describe 18 MET/week in minutes of mod-vig activity so it is easier to interpret for the readers? -What is the clinical relevance of these findings - beyond simply trying to get people to lose weight and be more active, which we already know to do. Could informing people of their potential trajectory give them more motivation to change? What does all this mean for future research? A few sentences on these points is needed <p>Tables</p> <ul style="list-style-type: none"> -Table 1. Define each cluster in the table footnotes so the reader doesn't need to go back to the text. Same for Table E1.
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	<p>Figures</p> <p>-Can you put the ≤ 50 and > 50 trajectories in the same figure? It is difficult to compare trajectories when they are separated. Same for the E-figures</p>
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VERSION 1 – AUTHOR RESPONSE

Responses to comments from reviewer #1:

Comment 1

Line 138-141: Please comment on the validity/reliability of the self-report instrument used to measure physical activity. Cite any publications that evaluate these, if applicable. If not, describe how the questions were developed and any aspects of the instruments that would suggest the tool is valid.
Line 140-141: Where were the MET-values for different activities obtained from? Please cite.

Response 1

We have now added two new references:

1. Kujala UM, Kaprio J, Sarna S et al. Relationship of leisuretime physical activity and mortality: the Finnish twin cohort. J Am Med Assoc 1998; 279: 440–4. <http://www.ncbi.nlm.nih.gov/pubmed/9466636>.
2. Ainsworth BE, Haskell WL, Herrmann SD et al. 2011. Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc 2011; 43: 1575–81. Doi:10.1249/MSS.0b013e31821ece12

The questionnaire on the level of physical activity has now been presented as Table 1:

Table 1. Defining the level of physical activity in the survey.

What was the intensity and frequency of your average physical activity (leisure or commuting) during the past year (or since the onset of your disease if the disease had begun less than a year ago)?					
Intensity (Mark all four options)	Amount per week				
	None	<½ hour	1 hour	2 – 3 hours	≥ 4 hours
Normal walking or respective					
Brisk walking or respective					
Light jogging or respective					
Brisk jogging or respective					

The responses were converted into MET units according to a following scheme.					
Intensity (Mark all four options)	MET minutes per week				
	None	<½ hour	1 hour	2 – 3 hours	≥ 4 hours
Normal walking or respective	0	69	138	345	550
Brisk walking or respective	0	99	198	495	792
Light jogging or respective	0	210	420	1050	1680
Brisk jogging or respective	0	240	480	1200	1920

Comment 2

Line 144: Similarly, do you have any data that suggests validity of self-reported height and weight in this cohort? Similar cohorts?

Response 2

Self-reporting as a weakness of this study has been discussed as follows:

“BMI was also based on self-reported weight and height, which may cause recall and information bias, possibly resulting in under-reporting of body weight (Connor Gorber S, Tremblay M, Moher D, et al. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes Rev* 2007;8(4):307-26.)”

Comment 3

Recommend swapping text in lines 171-176 as a table (Table 1); then the current Table 1 (goodness of fit characteristics) would be fine as a Supplemental Table. Nice to see the trajectory justification, but only for those that want to confirm the method was conducted correctly.

Response 3

We feel that there are not enough data in lines 171-176 to be presented as a separate table. We would like to preserve the Table 1 as the part of main text. Certainly, we will create a new table for demographics and place Table 1 in a Supplement if required by the Editor.

Comment 4

Trajectory (1 through 4) should be marked on Figures 1 and 2

Figures 1 & 2: the unit doesn't seem correct on the y-axis. Is this MET-hr per week – seems very high if so? MET alone is an intensity not volume of activity.

The text in 180-187 would likely fit better within the figures (as labels, e.g. for percentages of membership; and within a legend perhaps for the description of the PA level/BMI)

Response 4

We have now modified the figures.

We had initially tried to show additional information in the figures. Unfortunately, that led to a graphically disheveled result. The traj-module we used has a limited set of in-build functions. Adding texts afterwards in PowerPoint did not produce a professionally looked outcome.

Comment 7

It is nice how the BMI levels are interpreted based on accepted cut points of normal/overweight/obese. Interpretation of physical activity levels throughout could be improved if anchored to WHO guidelines (i.e., 150 min per week of moderate activity - can be changed to whatever unit is being used). For example, this could allow for more concrete statements in line 238-239 (was high above normal guidelines? by how much?)

Response 7

The categorization of physical activity levels has been defined in the methods section as follows:

“Weekly physical activity was expressed as MET-h/week and categorized as low (<14 MET-h/week), moderate (14 to <30 MET-h/week) or high (≥30 MET-h/week) physical activity levels.”

In order to ensure easier interpretation of the results, we have now added the following text to the Methods section:

“As recommended by the American Heart Association, 150 minutes of moderate-intensity aerobic exercise each week is needed for optimal cardiovascular health. That is equal to about 8.3 MET-h/week.”

Comment 8

Line 247 – MET-hr per week? MET/week is confusing.

Response 8

The typo has now been corrected.

Comment 9

Conclusion (both in line 257 and abstract): I am not sure you've proven that changes in BMI and physical activity are interconnected. Slightly more correct might be to say that changes in BMI and physical activity co-occur, given the observational nature of the study.

Response 9

We have now softened our conclusions as follows:

"Changes in BMI and physical activity might be interconnected."

Comment 10

The objective states explicitly to compare age groups, but then this is not mentioned at all in the conclusions. What is the public health impact of the differences across age groups?

Response 10

The following sentence has now been added to the Conclusions paragraph:

"The findings were similar for both age groups."

Comment 11

Another limitation is only looking at physical activity, rather than all day activity profiles. See this reference:

Gupta, N., Hallman, D.M., Dumuid, D. et al. Movement behavior profiles and obesity: a latent profile analysis of 24-h time-use composition among Danish workers. Int J Obes 44, 409–417 (2020). <https://doi.org/10.1038/s41366-019-0419-8>

Response 11

The limitation of physical activity has been stated in the Discussion as follows:

"Physical activity was self-reported and only leisure-time and commuting activity were inquired. Thus,

physical activity at work was not considered.”

Comment 12

In general, I’m missing an interpretation of the importance of these findings and future directions for additional research. Could a section be added to the Discussion?

Response 12

We have now added the following paragraph at the end of the Discussion section:

“The results may be of interest for both clinicians and stockholders when applying measures targeting increasing physical activity and controlling weight especially among people of middle-age. Additionally, the information on the established trajectories may give people more motivation to change their health behavior. Further research may reveal risk factors that affect developmental trajectories seen in this study. Such factors may be, for example, gender, socio-economic status, smoking, alcohol consumption and concurrent health disorders among others.”

Responses to comments from reviewer #2:

Comment 1

Could the authors provide more detail about the FPS? (e.g. sampling strategy, total sample size, what questions they are asked). What was the specific inclusion/exclusion criteria for this study? A flow diagram would improve understanding of the selection of the sample

Response

We have now added the following text to the Methods section along with two new references:

“The FPS has been described in detail somewhere else.”

1. Kouvonen A, Kivimäki M, Elovainio M, Pentti J, Linna A, Virtanen M, Vahtera J. Effort/reward imbalance and sedentary lifestyle: an observational study in a large occupational cohort. *Occup Environ Med.* 2006 Jun;63(6):422-7. doi: 10.1136/oem.2005.020974.
2. Kouvonen A, Kivimäki M, Virtanen M, Heponiemi T, Elovainio M, Pentti J, Linna A, Vahtera J. Effort-reward imbalance at work and the co-occurrence of lifestyle risk factors: cross-sectional survey in a sample of 36,127 public sector employees. *BMC Public Health.* 2006 Feb 7;6:24. doi: 10.1186/1471-2458-6-24.

Comment 2

Could the authors add more detail about how the models/trajectories are chosen/generated in the analysis section?

Response 2

Could it be possible to get some more information on what kind of details is needed?

Comment 3

Why was age stratified at ≤ 50 and > 50 ? Why not ≤ 40 and > 40 or ≤ 60 and > 60 for example?

Response 3

We have now added the following sentence to the Methods section:

“The cohort was divided in two approximately even age groups: ≤ 50 ($n=31,797$, 48%) and > 50 years ($n=35,055$, 52%).”

Comment 4

Was there any adjustment for co-variables in the analyses? If so, how these variables were collected and analysed should be outlined in the methods

Response 4

We have now added the following sentence to the Methods section:

“No adjustments for co-variables were made.”

Comment 5

Line 246: can you describe 18 MET/week in minutes of mod-vig activity so it is easier to interpret for the readers?

Response 5

The text has now been modified as follows:

“The distribution of physical activity intensity was skewed – most of the participants were at least somewhat active, and even in the least active group the mean activity level was approximately 18 MET-h/week, which is approximately the equivalent of three hours of brisk walking weekly.”

Comment 6

What is the clinical relevance of these findings - beyond simply trying to get people to lose weight and be more active, which we already know to do. Could informing people of their potential trajectory give them more motivation to change? What does all this mean for future research? A few sentences on these points is needed

Response 6

We have now added the following paragraph at the end of the Discussion section:

“The results may be of interest for both clinicians and stockholders when applying measures targeting increasing physical activity and controlling weight especially among people of middle-age. Additionally, the information on the established trajectories may give people more motivation to change their health behavior. Further research may reveal risk factors that affect developmental trajectories seen in this study. Such factors may be, for example, gender, socio-economic status, smoking, alcohol consumption and concurrent health disorders among others.”

Comment 7

Table 1. Define each cluster in the table footnotes so the reader doesn't need to go back to the text. Same for Table E1.

Response 7

Table 1 shows the goodness of fit for the different statistical models; whether 1 cluster or 5 cluster model best describes the sample. For more clarity, the tables have been edited.

Comment 8

Can you put the ≤ 50 and > 50 trajectories in the same figure? It is difficult to compare trajectories when they are separated. Same for the E-figures

Response 8

Unfortunately, this is not possible with the current version of traj-module for Stata or SAS software.

VERSION 2 – REVIEW

REVIEWER	Bethany Barone Gibbs University of Pittsburgh
REVIEW RETURNED	06-Jan-2022

GENERAL COMMENTS	<p>The authors have responded adequately to most of the requested revisions.</p> <p>The new Table 1, though informative, is a bit strange in the main publication - consider moving to an appendix.</p> <p>I also concur with the 2nd reviewer's Comment 8. Overlaying graphs is likely possible in an editing image software and should be revisited if at all possible.</p>
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REVIEWER	Joshua Zadro University of Sydney, Institute for Musculoskeletal Health, School of Public Health
REVIEW RETURNED	20-Dec-2021

GENERAL COMMENTS	<p>I thank the authors for responding to my previous comments. However, there are some that still require more attention.</p> <p>Comment 1: Please briefly include these details about the FPS in the manuscript. A base level of detail should be included so the reader doesn't have to go to the original FPS reference</p>
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	<p>Comment 2: Apologies if my comment wasn't clear. I was looking for a simple explanation for how the analysis chooses the trajectories (i.e. how similar do the trajectories have to be throughout the data collection period to be lumped together?)</p> <p>Line 131: <14 MET-h/week is defined as 'low physical activity levels', but meeting the WHO PA guidelines through moderate-intensity aerobic exercise is 8.3 MET-h/week. This seems contradictory. Is there a way to present minutes of activity as well as METs in this manuscript (or at least in the discussion/conclusions). I worry MET units wouldn't be interpretable to the average reader.</p>
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VERSION 2 – AUTHOR RESPONSE

Responses to comments from reviewer #1

<p>Comment 1</p> <p>The new Table 1, though informative, is a bit strange in the main publication - consider moving to an appendix.</p>
<p>Response 1</p> <p>We thank the reviewer for this opinion and have decided to move Table 1 to an appendix as table E1.</p>

<p>Comment 2</p> <p>I also concur with the 2nd reviewer's Comment 8 <i>[Can you put the ≤ 50 and >50 trajectories in the same figure? It is difficult to compare trajectories when they are separated. Same for the E-figures]</i> Overlaying graphs is likely possible in an editing image software and should be revisited if at all possible.</p>
<p>Response 2</p> <p>Unfortunately, limitations of the used software do not allow combining trajectories as suggested by the reviewers.</p>

Responses to comments from reviewer #2

<p>Comment 1</p> <p>Please briefly include these details about the FPS in the manuscript. A base level of detail should be included so the reader doesn't have to go to the original FPS reference</p>
<p>Response 1</p>

More detail in the FPS has now been included in the 'Methods' section as follows;

"Participants were drawn from the Finnish Public Sector (FPS) cohort study, a dynamic cohort with follow-up intervals two to four years initiated from 1998/2000. It consists of employees in the municipal services of 10 Finnish town and 21 public hospitals, who had a job contract for a minimum of 6 months. In year 2000, the most common occupations of the respondents were registered nurse (23%), teacher (19%), practical nurse (13%) and cleaner (10%). The FPS has been described in more detail elsewhere.^{12 13} Data in the current study included responses to five questionnaire surveys administered in 2000-2002, 2004-2005, 2008-2009 and 2016-2017 to 2017 (average response rate 70%). The baseline was the response given in 2000 or in 2004. The baseline was the response given in 2000-2002 or 2004-2005. Participants who had reported their BMI and physical activity in at least two waves were included in the analysis."

Comment 2

Apologies if my comment wasn't clear. I was looking for a simple explanation for how the analysis chooses the trajectories (i.e. how similar do the trajectories have to be throughout the data collection period to be lumped together?)

Response 2

We thank you for a more clear comment.

This depends on the amount of trajectories chosen. In theory, it is possible to find 66,852 different trajectories, but we used the commonly used criteria that the smallest group has to include at least 5% of the participants. This way four trajectory groups were chosen. The analysis is performed by testing with different amounts of trajectory groups, first with one, then with two groups etc., until there are so many groups, that the smallest group is smaller than the pre-agreed cut-off (in this case, 5%). The analysis lumps together trajectories that are more similar with each other than other trajectories and the level of similarity thus depends on the amount of groups. To test which model (in this case, 4-cluster) best describes the population, we used Bayesian information criterion (BIC) and Akaike information criterion (AIC) and smallest average posterior probability (APP), which are presented in Table 2.

This is now described in more detail in the 'Methods' section as follows;

"Group-based multi-trajectory analysis (GBTA) was used to distinguish different developmental trajectories for physical activity and BMI, both treated as continuous variables. This method is a form of finite mixture modeling for analyzing longitudinal repeated measures data. While conventional statistics show a trajectory of average change of outcome over time, group-based trajectory modeling is able to distinguish and describe subpopulations (clusters) existing within a studied population. A censored (known also as 'regular') normal model of group-based multi-trajectory analysis was used. The goodness of model fit was judged by running the procedure several times with a number of trajectory clusters starting from one up to five, until the smallest group was below the pre-agreed cut-off at >5%. The Bayesian Information Criterion (BIC), Akaike information criterion (AIC) and average posterior probability (APP) were used as criteria to confirm the goodness of fit. A cubic regression was applied."

Comment 3

Line 131: <14 MET-h/week is defined as 'low physical activity levels', but meeting the WHO PA

guidelines through moderate-intensity aerobic exercise is 8.3 MET-h/week. This seems contradictory. Is there a way to present minutes of activity as well as METs in this manuscript (or at least in the discussion/conclusions). I worry MET units wouldn't be interpretable to the average reader.

Response 3

We are sorry about the vagueness of the description. To improve readability, we have now clarified the categorization in more detail and justified it based on previous studies studying the association of physical activity and different health outcomes ("This categorization was chosen since physical activity higher than 14 MET-h/week has been reported to be associated with cardiovascular disease¹⁷ and the activity level of 30 MET-h/week has been shown to be needed for weight management¹⁸. 14 MET-h/week is approximately the equivalent of 140 minutes of brisk walking weekly."). We thank the Reviewer for the suggestion to present the findings in minutes. However, this is challenging given the physical activity measure available. The MET-values take into account different types of activity with different intensities, so that for instance running for one hour at the pace of 10km/h results in a MET-value of 10 MET-h/week, as well as does walking for two hours at the pace of 6km/h. That is why we have decided to present the findings in MET-values. We have also added to the Discussion a comment explaining what does the average activity in population means in practical terms. I.e. mean activity in this study population (18 MET-h/week) equals approximately three hours of brisk walking per week.